The Lunar Polar Regions as Solar System Analogs.
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Introduction: The lunar polar regions are ready made laboratories for studying surface chemistry and processes and testing technology necessary to support such scientific activity throughout the solar system.

Lunar Surface Processes and Conditions: The temperature of a smooth surface (without shadowing) at the poles would range from about 50K to about 300K [1]. However, the polar regions experience lower sun angles, and have rugged topography, and a bombardment saturated terrain which includes boulder populations. This creates a large variety of 'microniches' with degrees of illumination (during a diurnal cycle) varying from constantly illuminated (so-called 'points of eternal light', with temperature nearly constant at the upper end of that range) to permanently shadowed (with temperature nearly constant at or below 40K. Only half a meter below the surface, temperatures are a nearly constant average of surface temperatures above. These microclimates could be extremely local niches: beneath a rock or on a slope with an overhang above it, or more extensive, as in permanently shadowed craters. Studying grain surface chemistry induced interaction or lack of interaction due to shielding from fields, particles, dust, solar wind, and exosphere, would provide insights into space weathering processes affecting most of the (regolith covered, bombardment dominated) surfaces in the solar system. Grain surface chemistry with hydrogen and hydrides, as will as silicate surface chemistry involving 'volatile incompatibles' (to silicate matrix) cations could provide clues as to volatile origin (interior, meteoritic, solar wind, or trapped exosphere). These microclimates could also stand in as analogs for a variety of solar system environments with distinctive chemical interactions enabled under the conditions within selected microniches.

The Moon as Surface Condition and/or Temperature Analog for many targets: As illustrated in the table [2], surface conditions on a variety of targets, including NEOs, Mercury (lower range), and icy moons, overlap with those on the lunar surface. Temperature ranges for the outer planets and Mars fall within temperature ranges on the Moon. The nature of and extent to which surface constituents are involved in surface and subsurface processes depends on their volatilities, and thus on effective surface temperatures and illumination on atmosphereless bodies [2,3]. This means the lunar surface could act as a testbed, either as as a chemistry laboratory for surface processes in the solar system, or as a proving ground for technologies that reduce resource consumption while improving capability (e.g., ultra low temperature ultra low power electonics), resulting in higher value and lower cost exploration of the entire solar system.

References: [1] Clark P.E. et al (2011) AIP Conference Proceedings, SPESIF (in press); [2] Zhang J.A. and Paige D. A. (2009) GRL, 36, L16203, doi:10.1029/2009GL038614; [3] Paige D. (2010), Science, 330, 479, DOI: 10.1126/science.1187726.

Target	Processes	Temperature Range
Moon	grain surface chemistry. space weathering. bombardment of silicate surface. volatiles, exosphere processes	<40 – 400K
NEOs	grain surface chemistry, space weathering. bombardment, for silicate surface but with higher volatile, organic, metallic iron	<40 – 350K
Mercury	grain surface chemistry, space weathering. Bombardment for silicate surface, with higher volatile content including water (discrete ice layer) and sulfur	<40 – 650K
Mars	bombardment plus volcano–tectonic activity for silicate surface with seasonal volatile atmosphere, polar deposit circulation, subsurface hydrothermal processes, wind (dust), volatiles as erosional agents. sulfur chemistry	135 – 325K
Outer Planets	water, methanol, ammonia, formaldehyde, carbon dioxide, hydrogen sulfide, sulfur dioxide chemistry	80 – 175K Jupiter 30 – 150K Saturn 60 – 70K Uranus 50–55K Neptune
Icy Moons	grain surface chemistry, space weathering, bombardment (for atmosphereless), volatiles ionization, organic and sulfur chemistries	<40 – 100K
Molecular Clouds	grain surface chemistry involving hydrogen and hydrides.	<90K